

Divide may expect an annual rainfall of less than 15 inches in over half the years, although some western localities very rarely have less than this. In North and South Dakota the percentages drop off rapidly to the eastward, ranging from around 40 to 50 in the western parts to mostly less than 10 along the eastern borders.

Figure 1 has a bearing on the question of duration and intensity of droughts. The data shown are annual precipitation by 5-year moving averages; that is, each point on the graphs represents the average for the 5 years up to and including that year. The long-record graph for St. Paul, Minn., is included for comparison with the shorter periods of the stations in the area concerned. Some of these necessarily are combinations of records for nearby stations in order to obtain as long a period as possible. Thus, the data for Williston, N. Dak., represent not only those for Williston, but also those for Buford, N. Dak., a nearby station with an earlier record than is available at Williston.

Similarly the record for Pierre, S. Dak., is combined with a record for Fort Sully, S. Dak., also a nearby station with earlier data. While all of the data are not strictly homogeneous they show the general tendency of precipitation in this area.

The record for St. Paul covers the years 1836-1934, inclusive, while the others are shorter. The sparse settlement of much of this area in the earlier years prevented complete coverage, and it was extremely difficult to maintain continuity of records.

The really encouraging indications of these graphs are the recoveries that were made after previous depressions rather similar to that now prevailing. The trends for Yankton, S. Dak., follow those for St. Paul closely, but in general the stations tend to less variation as they progress westward. Miles City, Mont., shows a long-time drop in annual rainfall similar to St. Paul, but most of the other stations show general tendencies to dryness only during the last few years; for instance, for Williston, N. Dak., the annual trend has just started down, indicating that perhaps this region is tending toward a series of dry years.

The most important feature in all these graphs is the fact that for every series of years with subnormal rainfall there is a subsequent recovery with above-normal amounts for several years. The periods are far from uniform in length, as is readily apparent, but the most striking thing is the alternation of depressions and recoveries just mentioned.

Grateful acknowledgment is made of the invaluable aid and advice freely given by Mr. J. B. Kincer. Acknowledgment is also made of the material that was taken from Kincer's article on the climate of the Great Plains (2).

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## METEOROLOGICAL EXTREMES OF THE SOUTHWEST

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[Southwest Missouri State Teachers College, Springfield, August 1934]

The average person remembers the unusual weather which he has experienced, and forgets the normal course; and of this unusual weather, he is likely to remember only that which occurred most recently or which may have made some deep impression upon him at the time. If, as a child, he had an unusual experience of wading through snow up to his hips on Thanksgiving Day, that fact clings to his mind for years; and because no other Thanksgiving since then may have had snow that deep, he knows that the weather isn't what it used to be, notwithstanding that snow, hip deep, to a child might not need to be much more than a foot deep. It may seem, therefore, that the subject here treated would only be aggravating a situation already bad. That can hardly be the case, however, because probably no reader of this article has experienced as much as 5 percent of the phenomena or conditions which are portrayed. To the student of human climatology a knowledge of extremes of weather is quite as significant as a knowledge of averages, since the extremes cause so much property loss and human suffering. The extremes noted here do not in any sense comprise all those observed in the Southwest over even a recent period, for only a small percentage ever find their way into print; and necessarily the source of information herein contained is almost wholly from published records.

Temperature extremes seem to interest the greatest number of individuals, for there is no one who is not affected directly by them unless he should be so fortunate as to be able to seek a more congenial clime when temperature extremes are greatest, namely, in summer or in win-

ter. The person living in a substantial city apartment is less directly affected by drouths and floods, snow and rain, wind and hail, than by temperature.

The most pronounced extremes of temperature seem to be in Colorado, at elevations between 5,000 and 10,000 feet. Pagosa Springs, in the southwest portion of the State, has an absolute range of temperature of 156°, from 95° in July to 61° below zero in February, which was attained during the cold wave of 1933 (1). During that same cold wave, the temperature at Silverton, in western Colorado, dropped to 56° below zero, giving it an absolute range of 149°. Of course, large ranges of temperature are experienced elsewhere than on the Colorado plateaus; Warsaw, Mo., for instance, with an elevation of only 715 feet, has an absolute range of 151°, from 115° in July to -36° in February.

Of all of the southwest portion of the United States, least absolute ranges of temperature are found in southern Texas and Louisiana. The smallest range is 80° at Bay City, Tex., where the highest temperature recorded was 98° in both July and September and 18° in January. San Benito, in southwestern Texas, has an absolute range of 82°, while Louisiana's smallest absolute range is found at Carrollton, 83°. During a 50-year period, the highest temperature recorded in Palestine, Tex., was 108° in August, while that at Port Arthur, Tex., was 102° in June; Palestine's minimum, however, is 6° below zero for February, and that of Port Arthur is but 11° for January. Gulf waters presumably cause these differences.

Even places on the Gulf have their cold waves. At Galveston, Tex., in February 1899, the temperature dropped to 7.5°, causing fish which were caught in shallow warm water to die from chill before reaching deep water

<sup>1</sup>Actively assisted by Mary Botts, Helen McBride, and William Raney, research students. In many instances, new records for drouth and high temperature were established during the summer of 1934.

(2). During a severe cold wave on the Texas coast in January 1918 the temperature fell from 63° to 16° in 12 hours, and this in spite of the warm waters of the Gulf (3).

It appears that the highest temperature ever recorded in the Southwest was 127° in July at Parker, Ariz. Maricopa, Ariz., has had a June temperature of 126°. According to States, Kansas ranks second in high temperatures, for it was reported that during a general period of hot winds in western Kansas in September 1931, 120° was reached. This report, however, has been considered very doubtful by the Kansas section director of the Weather Bureau (4). Before this, Kansas' highest temperature was 116°, recorded in June at Hugoton. One hundred eighteen degrees, recorded in August at Oakwood, holds the record for Oklahoma's high temperatures, while the highest in Texas was 117° in June at Big Spring. Missouri's highest temperatures were recorded in July at Marble Hill and Warsaw, where they read 116° and 115°, respectively. Garfield, N. Mex., recorded a temperature of 114° in June and 110° in May. Louisiana's highest temperature was reached in August, 112°, at both Liberty Hill and Minden. Prescott, Arkadelphia, and Hemp Wallace, all in Arkansas, have maxima of 111° in August. Colorado's highest temperature, 111°, was recorded at Two Buttes in July and August.

The highest January temperature recorded in Texas was 96° at Fort Stockton. Rio Grande, Tex., has had a February temperature of 104°, and also the highest March temperature on record, 108°. Parker, Ariz., which had the highest temperature recorded, also has the maximum recorded for April, 113°. Two other points in Arizona, Aztec and Casa Grande, hold the record for May, of 120°. Buckeye, Ariz., has registered 114° in October, while Maricopa, Ariz., and Fort McIntosh, Tex., hold the November record with temperatures of 101°. The highest December temperature recorded in the Southwest was 98° at Encinal, Tex.

The lowest temperature recorded in the Southwest was -61° at Pagosa Springs, Colo., as already stated Missouri's lowest temperature was recorded at Warsaw, -36° in February. New Mexico's minimum is also -36°, recorded at Haynes in December. Atwood, Kans., with a January low of -33°, experienced the minimum for that state. Chin Lee holds the minimum record for Arizona with a December temperature of -32°. Arkansas' minimum is -29° and Oklahoma's is -23°. Louisiana's lowest temperature was -16° recorded in February at Minden, which also had the highest temperature recorded for Louisiana. There have never been any subzero temperatures recorded in southern Louisiana; the lowest temperature reached there was 1° in February at Amite and near Hammond. Subzero temperatures have been recorded only twice in Dallas, during a 43-year period. The last time was in January, 1930, when the temperature fell to 3° below zero.

Normally, the lowest temperatures of the year come in December, January, or February. In 1932, however, Fort Smith, Ark., experienced 13°, the lowest temperature of the year on March 9, and this is the lowest March temperature of record, having followed a February with a daily excess of 8°. The lowest temperature ever recorded at San Benito, Tex., is 25°; all other stations in the Southwest have recorded lower temperatures.

As has already been stated, the lowest annual absolute minimum for this section is -61° in February, Pagosa Springs, Colo. The lowest minimum of the hottest month is 25° for June and July at Buena Vista, Colo. The absolute highest minimum of the hottest month is

73° in August, at Port Isabel, Tex.; that is, at no other station in the Southwest has the warmest month passed without temperatures going below 73° during at least 1 night.

One of the greatest overnight changes in temperature occurred at Amarillo, Tex., February 7, 1933, when the temperature dropped 70°, from 64° to -6° (5). Almost as great a change occurred in Oklahoma City November 11, 1911. At 1 p. m. the temperature was 83°; at 3:30 p. m., it was 32°; and at midnight, 17°. At 3 a. m. of the following day, it was 14°. Eighty-three degrees and 17° are still the highest and lowest of record there for November 11 (6). Springfield, Mo., also experienced a sudden drop in temperature in November 1911. At 3:45 p. m. the temperature was 80°, which broke a 25-year record for that month; during the night the temperature fell to 13° (7).

The most severe and one of the most recent cold waves of the Southwest was that of February 1933. This caused the unprecedented low temperature at Pagosa Springs, Colo. New Mexico and Texas also experienced cold waves during this period, following abnormal January warmth. The Great Basin States, including the northern part of New Mexico and Arizona, had markedly subnormal temperatures during the winter of 1933, averaging 5° to 10° below normal, making it one of the coldest winters of record in those States (8). There were two severe cold waves in the Southwest the latter part of January 1930. In Texas this was the most severe cold wave in a period of 30 years (9). At scattered places at high altitudes in Colorado, Arizona, and New Mexico, the temperature fell to between 30° and 40° below zero on November 25, 1931 (10). In 1918, there was a severe cold wave on the Texas coast, with a sudden drop in temperature from 63° at 11 p. m., January 10, to 16° at 11 a. m., January 11 (11). During the cold wave of 1918 and 1919, Amarillo, Tex., had 37 consecutive days with temperatures of 32° or less. In December 1923, the average daily temperatures for the 2 weeks of cold weather, following a snow storm in the southern mountain and plateau states, were from 10° to more than 30° below normal (12).

During a period of hot winds in the summer of 1930, the highest temperature of record in western Kansas was reached in September, when the thermometer is said to have registered 120°. From July 4 to August 16 of that year, 39 out of 44 days had temperatures of 100° or more. This hot wave included most of the Southwest. In Texas, the period of high temperatures started June 17 and ended August 25. Each of those 70 days had temperatures of 100° or more. During the same period in Oklahoma, 64 days out of 66 had temperatures of 100° or more, and Arkansas and Missouri both had more than 1 month with temperatures 100° or more.

There was a hot wave in 1913, affecting particularly Texas and Arkansas. In Arkansas there were 13 days with a maximum temperature of 100° or more, while in Texas there were 6 days (13). There was abnormal warmth during June 1933 in the Middle West. The extreme heat prevailed during two distinct periods, interrupted, however, by a spell of very cool weather. The first hot wave prevailed over most of the country east of the Rockies from the 3d to the 11th. Temperatures exceeded 100° at many stations, while 110° was recorded at Wichita and 106° at Concordia (14). Brownsville, Tex., once had 105 consecutive days with a maximum of 90° or above, from May 23 to September 4, 1900.

A rather unusual condition exists around Corpus Christi, Tex., where the maximum temperature on most

of the days comes between 11 a. m. and 1 p. m. (15). Brownsville, Tex., averages about 1 day in 10 years with a temperature of 18° or lower, and 1 day in 50 years with a temperature of 15° or lower.

Of all the United States, the Southwest, particularly the normally drier portions, has the most erratic rainfall. For a given period the average is seldom experienced. Droughts and floods in varying degrees of severity are to be expected almost every year. It was during August 1922 that ranches throughout most of the Southwest were unfavorably affected by dry weather. At the close of the month, cattle were in poor condition in most of New Mexico and west Texas (16). On the other hand, torrential rains in southern and central Texas during September 1921 caused floods which resulted in the death of 215 persons and in damage to property amounting to more than \$19,000,000 (17).

Records are replete with accounts of excessive precipitation. In all the Southwest probably the greatest single fall of rain was near Taylor, Tex., during the night of September 9 and 10, 1921. A total of 30 inches was recorded in 15 hours, thus averaging 2 inches per hour (18). Torrential rains over the southeastern portion of Texas in May 1923 resulted in Beaumont recording nearly 14 inches, and it was reported that the entire amount actually fell in 2½ hours (19). In June 1913 nearly 21 inches of rain fell in 18 hours at Montell (20). Brownsville received 12 inches in 24 consecutive hours in September 1886, which helped raise the month's total from a mean of 5½ inches to an excess of over 25 inches. Opid's Camp on the west front of the San Gabriel Range reported that slightly over 1 inch of rain fell in 1 minute on April 5, 1926 (21). Four inches fell in 1½ hours at Concordia, Kans., on June 23, 1904.

Precipitation for November 1931 was abnormally heavy over an area including eastern Kansas and central Oklahoma, which reported four to six times the normal. Phoenix, Ariz., received nearly five times its normal (22). During April 1931 the precipitation at El Paso, Tex., was eight times the normal for the month and was 160 percent of the greatest previous April fall in the 50 years of record (23). Galveston, Tex., reported May 1929 as having the greatest rainfall for the month in over 50 years (24).

Missouri's greatest annual fall of rain, of a little over 70 inches, occurred at Cassville in 1895. Leroy, Kans., recorded 65 inches in 1915; Calvin, Okla., 70 inches in 1908; and Arkadelphia, Ark., 93 inches in 1905. At Clarksville, Tex., 109 inches is the record established in 1873. During May, June, and July of the same year a total of 53 inches fell. Harvey's ranch, New Mexico, recorded 51 inches in 1919. Pinal ranch, Arizona, recorded 58 inches for the year 1905. The greatest annual fall for Louisiana occurred at Alexandria in 1923, with a total of 88 inches.

In the more or less semiarid portions of the Southwest the fall of rain in abnormal quantities often causes great damages to prospective and matured crops by disastrous floods in the otherwise dry river channels. Outstanding floods of 1923 were those of the Arkansas River from Eastern Kansas to the river's mouth, the Neosho River of Kansas and Oklahoma, and the Cimarron and Canadian Rivers of Oklahoma. Four weeks of almost continuous and frequently excessive rains brought about these floods, the crest stages of which were as a rule higher than any previously recorded. The floods came at the time of matured wheat and growing corn and covered nearly 300,000 acres of productive land in southeastern Kansas and northeastern Oklahoma. The loss and damage,

mainly to crops, amounted to approximately \$28,000,000 (25). There was more rainfall received than normally expected in April during 1922 from central Texas north-east to the lower Ohio valley. Monthly amounts ranged up to as much as 18 inches and in portions of Kansas and Oklahoma precipitation was the greatest of record for the month (26).

At Phoenix, Ariz., in February 1931, 300 tourists who had been driven from auto camps at Wellton by a flood which followed a cloudburst 2 days previously had to be fed because they were stranded by impassable roads (27). During the flood of the Trinity River at Fort Worth, Tex., in April 1922, 11 persons were drowned, with many others missing. The flood waters were derived from heavy rainfall during a severe electrical storm (28). Unusually heavy rainfall in southeastern Arizona during September 1926, resulted in the crest of the Gila River, near the town of Kelvin, reaching 11 feet above flood level (29). The Brazos River flood of May 1922, reached a crest stage at Kopperl, Tex., of 48 feet, or 27 feet above the flood stage. This was 11.5 feet above the previous high-water mark of November 1918. Property damage totaled approximately \$1,750,000 (30).

Excessive precipitation of from 7 to 12 inches during August 1922, in the vicinity of Enid, Okla., and the Cimarron Basin caused the Cimarron River to flood, resulting in the washing out of 19 bridges in Woods County and 18 in Logan County. Two boys were drowned at Oilton, and over 150 square miles of cultivated lands were under water which stripped away the surface soil. Damages totaled several hundred thousand dollars (31). Torrential rains in Comanche County, Tex., in September 1910, resulted in a disastrous flood which swept down the narrow channel of the Leon River in a 25-foot wall of water, killing 13 persons (32). Heavy local mountain rains caused a flood in the Galisteo River, a tributary of the Rio Grande, in New Mexico during August 1924. The town of Lamy was inundated with a probable loss of \$500,000 (33).

The Southwest as a whole is subject occasionally to falls of hail which do a vast amount of damage in a short time not only to crops, but also to property and buildings. Reports of outstanding hailstorm losses during 1929 from Kansas totaled \$2,400,000 with countless minor losses not reported. Fifteen of the 38 storms came in June. During 1928 Kansas suffered losses of \$1,000,000 or more from each of six hail storms (34). The year 1927 was characterized by 6 days, each with very heavy hailstorms in Oklahoma, Kansas, Colorado, and Texas; the total loss amounted to \$7,000,000. Estimates of loss in 1927 from 298 hailstorms totaled \$15,000,000; while during 1926, \$12,000,000 was the loss in 295 storms (35).

In May 1926 a destructive hailstorm in northeastern Texas damaged property to the extent of several million dollars, the greatest damage being in and around Dallas. The hailstones were reported to be the size of moth balls, hen's eggs, and baseballs, some weighing 22 ounces. Scores of people were injured, crops and fruit orchards destroyed, and cows and horses killed (36 and 37). In July 1924 a strip of hail 40 miles long and 3 to 7 miles wide fell in Stevens County, Kans., ruining 30,000 acres of wheat. During a tornado at Rocksprings, Tex., in April 1923, hail fell that measured 2 inches or more in diameter, up to the size of baseballs. The noise of its falling on housetops could be heard one-half mile away (38). An unusually severe hailstorm swept a path 5 miles wide across Grove and Lane Counties, Kans., in June 1928, leaving fields in the path bare. Horses, cattle, hogs, sheep, rabbits, chickens, and birds were killed.

Hailstones piled into drifts 8 to 15 feet deep, many of which remained for 3 days afterward (39). Fine stands of wheat in Kansas were destroyed by hail in June 1928, causing a loss of \$2,000,000 (40). Stanton, Morton, Grant, Haskell, Seward, Meade, and Clark Counties, Kans., suffered one of the worst hailstorms in history in June 1928; crops and property for 140 miles were damaged to the extent of approximately \$3,000,000. Grayson, Lamar, Fannin, Delta, Denton, and Smith Counties, Tex., in May 1926, were damaged \$1,700,000 by hail. In June 1931, at Warsaw, Mo., hailstones as big as baseballs fell with such force as to strip homes of weather boarding, kill poultry, birds, and livestock. Ice was formed a foot thick and piled up 3 feet deep immediately after the storm (41). The most severe hailstorm that ever visited Corpus Christi occurred in May 1924. Hail one-half inch in diameter fell continuously for almost an hour, associated with strong north winds, vivid lightning, and torrential rainfall of 1.65 inches in 38 minutes (42). Wray, Colo., in June 1927, lost about 50 percent of its crops from hail. At Roswell, N. Mex., in October 1930, car tops were perforated, windows were broken, buildings damaged, and cotton and alfalfa crops were beaten by an 1,800-yard-wide path of hail that caused \$90,000 damages. Barton, Pawnee, and Stafford Counties, Kans., in June 1927, were damaged to the extent of \$2,000,000 by a 30-mile-wide path of hail.

In January 1929 no other Weather Bureau station in the plateau region had so much snow on the ground as Flagstaff, Ariz. The deepest snow, 19 inches, was about 100 miles north of Flagstaff (43). A few days before Christmas 1929 Texas was visited by a snowstorm of unusual severity, which paralyzed traffic in the central part of the State. In the panhandle of Texas heavy snows are common, but in central Texas snows are rare, while farther south near the Gulf and along the Rio Grande snow is practically unknown. In this storm northeast Texas had no snow, while central and southern Texas had very heavy snows, 26 inches falling at Hillsboro (44). Ten inches of snowfall on Pike's Peak in June 1928 marooned 25 tourists (45). In December 1924 sleet and snow impeded Oklahoma's railway and street traffic and damaged overhead wires to the extent of \$500,000.

Corpus Christi, Tex., and the surrounding counties suffered from damages to trees, flowers, citrus-fruit trees, and telephone and telegraph lines by ice and sleet in December 1924. In 1911 at Springfield, Mo., the first snow of the season fell in October; and from then to March the total amount was 53 inches as compared with the average annual snowfall of about 15 inches. During January 1912 in the same city the ground was covered for 24 days; snow occurred on 41 days, and on the 20th of February a total of 20 inches was recorded, which exceeded all previous 24-hour snowfalls, and was more than had ever before been recorded in a single month (46). Beginning late in November 1923, snow overspread the panhandle of Texas and extended into eastern Kansas, western Missouri, and Arkansas. Locally in eastern Kansas the fall was the greatest reported for the entire month of November for any previous year (47). Snow fell throughout Arkansas in January 1910, the depth ranging from 1 inch in counties bordering Louisiana to 10 inches in the upper Ouachita Valley. This distribution is unusual, as the heaviest fall of snow usually occurs in the northern part of the State (48).

A sleet and ice storm of great severity occurred at Corpus Christi, Tex., during December 1924. The coat-

ing on the wires and trees was so heavy as to cause wires to break. In the latter part of the month there was an inch of snow and sleet on the ground, a very rare occurrence for that section (49). In December 1929 States bordering the Gulf from Texas to Alabama reported the greatest average snowfall on record for the month (50). Alexandria, La., received 8 inches of snow during December 1901. This was the greatest fall on record.

In December 1923 a storm attended by heavy snow spread over the southern mountain and plateau States centering over New Mexico. Drifting snow completely tied up automobile traffic and nullified railroad schedules. This was followed immediately by much colder weather (51). During December 1924 snow occurred as far as the extreme southern part of Texas, amounts of 1 inch or more being reported from the lower Rio Grande Valley (52). During January 1930 moderate amounts of snow fell much farther south, particularly in Texas and the Lower Mississippi Valley. In Oklahoma the amount was 50 percent above that of any previous January (53).

In the Arkansas River from Cimarron to Wichita, Kans., ice jams in early February 1924 were productive of local floods. The ice conditions were said to have been the severest in the history of the State of Kansas. The ice extended for over 300 miles (54). According to a newspaper dispatch, the Rio Grande at San Marcial, N. Mex., during the latter part of December 1932, was blocked by ice for the second time in history (55).

The antithesis of rain, snow, hail, and flood is drought. The readily remembered 9-month drought of 1930 reduced the precipitations of many States to much below normal, Arkansas having the lowest record of all (56). During August and September 1933 a drought occurred in southwestern Kansas which caused a migration of thousands of jackrabbits from the parched lands to greener pastures. Lane and Ness Counties were swarming with rabbits. A traveler reported that he found it almost impossible to drive along the country roads without killing them. It was here that wheat was almost a complete failure and crops planted in the spring did no better (57).

A severe drought occurred at Springfield, Mo., during May and June 1911, which was almost without rain, breaking all records in this locality for continuous dry weather for that time of year. In Oklahoma, June of the same year was the driest month on record, causing a scarcity of water for stock. It was during 1911 that Kansas and Missouri had the hottest and driest weather on record for the month of June (58). In 1930 Missouri had the driest July in more than 60 years. The same year was the second driest on record in eastern Kansas. While drought prevailed over the United States, Colorado had more rain in July than any other July except 2 in 43 years of climatological history (59).

During 1924 and 1925 a drought continued for over a year in New Mexico, and in parts of Arizona the water supply was the lowest ever known. These States received practically no snow, which is very unusual (60). At Oklahoma City, during August 1922, there was recorded the least amount of precipitation ever observed for the month at that station. Portions of eastern New Mexico had a drought that persisted through June, July, and August, resulting in the driest summer ever known (61). One of the most serious droughts in the history of the State of Arkansas occurred at Little Rock in 1930. It lasted for 107 days during which less than 1 inch of rain fell (62). July 1924 was the driest on record at points in eastern Texas and was among the driest on record at points in Arkansas and Louisiana (63).

With an average of over 27 inches of precipitation, Brownsville, Tex., frequently suffers long droughts. The longest period of drought on record was during the years 1893 to 1902, a period of 10 years. During that time rainfall did not total as much as 20 inches in any 1 year. This drought led to the development of irrigation and convinced farmers of its worth (64).

The weather during the month of December 1910 was the driest on record in New Mexico, while in Oklahoma the long-continued drought of the same year was the cause of the poorest stand of wheat in the history of the State (65). The drought of 1929 in Texas was the severest and longest dry period of record during the growing season. This drought started in the central part of the State about the close of May and continued persistently for over 3 months, during which period the total rainfall at Dallas was only 1 inch. Crops were materially damaged by the continued hot, dry, and cloudless weather. Cotton was so poor that a second picking would not pay for harvesting, a condition which seldom occurs. This drought, however, was partially relieved on September 5 and 6 (66).

In September 1925 the cotton crop was seriously reduced in yield from central Texas southward because of the lack of rain (67). Southern Texas and the north plains received only 50 percent, or less, of the usual amount of rainfall during January 1932 (68). From October 1851 to May 1852 only slightly more than 1 inch of rain fell at Albuquerque, N. Mex. At Roswell the continued lack of rain during June 1925 had resulted in lowering the flow of water from artesian wells to unprecedented levels; and where they normally flowed spontaneously it became necessary to resort to pumping, and even that failed in many wells (69). The precipitation was noticeably deficient at all stations in Missouri during March 1910. In general the total amount of rainfall was only about 14 percent of the normal (70).

Lightning struck oil tanks, causing a \$250,000 loss during a wind, rain, and electrical storm in August 1924, at Tulsa, Okla. A severe thunderstorm southeast of Dodge City, Kans., in August 1924, caused the death of 1 person and 5 horses. In a thunderstorm at Port Arthur, Tex., in July 1931, lightning caused an explosion and fire on an oil barge, resulting in \$73,000 damages and the loss of one life.

Probably the most dreaded of extreme meteorological conditions of the Southwest is the tornado because it arrives with so little warning. Fortunately, this phenomenon becomes less frequent with progress westward, although winds of high velocity are not infrequent. Thus, on April 5, 1895, Amarillo experienced a northwest wind with a velocity of 84 miles per hour, probably one of the highest on record, while at El Paso on the same date the wind blew 78 miles per hour. Galveston seems to hold the record for the Gulf coast with 71 miles per hour, registered August 17, 1915 (71). These high winds are exclusive of those which occur in hurricanes and tornadoes; these are vastly more violent.

Arizona seems to be the least affected by high winds of a serious nature, although a wind velocity of 58 miles per hour was recorded at Flagstaff one October. There was a rain, hail, and wind storm in August 1928 at Phoenix, Ariz., which caused \$100,000 damage to communication lines and business houses. This is the only storm of consequence found recorded in that State. There is one interesting story, however, told of the Arizona winds and international relations: In April 1929 rebel bombs intended for Naco, Sonora, were apparently blown by the prevailing south wind over Naco, Ariz. (72).

Colorado has evidently had few destructive tornadoes compared with such States as Kansas, Arkansas, or Texas. The only serious one recorded for the southern part of this State is a tornado and hailstorm near Fowler, in October 1930. The path of this storm was about 880 yards wide. Three persons were killed, and three others were injured. The property damage was estimated at \$30,000 to houses, farm buildings, and equipment; three automobiles were totally wrecked.

The worst tornado recorded in northern Louisiana was in Caddo and Bossier Parishes, May 13, 1908. The tornado's path was over one-fourth mile wide, and 20 miles long. Forty-nine lives were lost, and the property damage was estimated at \$70,000 (73). Another destructive tornado was that of April 4, 1923, at Pineville and the northern part of Alexandria, in which 14 persons were killed, with a property damage of \$750,000 (74).

Arkansas appears to have been visited by tornadoes more frequently than other of the Southwest States. This partial record shows how wide-spread they may be: 34 on June 5, 1915; 28 on November 25, 1926; 25 on May 9, 1927; and 22 on April 10, 1929. In those of April 1929, 68 lives were lost, with a property damage of \$830,000. During the period from 1916 to 1923, 76 tornadoes occurred in Arkansas. In these, 231 persons were killed, 91 of them in 1916 alone. These 76 tornadoes resulted in \$2,400,000 damage; and in the year 1921 the total loss from tornadoes was \$1,500,000. In the Green Forest tornado of 1927, 22 persons were killed and 100 injured. There was a great property loss (75). In the Heber Springs tornado, November 25, 1926, 20 were killed, 75 injured, and there was a property damage of \$400,000. At Hot Springs, November 25, 1926, 10 lives were lost and 45 persons were injured in a tornado which was approximately one-fourth mile wide and 9 miles long; there was \$300,000 property damage (76).

Damage from winds and tornadoes in New Mexico and Arizona is relatively infrequent. Albuquerque seems to have the record for high wind in New Mexico, 63 miles per hour. On May 31, 1930, however, a tornado did pass through Wagon Mound, N. Mex. More than 40 homes and 8 business houses were destroyed, with a loss of 3 lives; 20 persons were injured, and \$150,000 damage done to property (77). Just about a year later, a tornado passed through French, Colfax County, 35 miles northeast of Wagon Mound, and on into Union County. Buildings were damaged, and a 3-year-old girl died of injuries received. The storm path was 90 miles long (78).

The St. Louis tornado of May 27, 1896, killed 72 persons, injured 500, and caused \$22,000,000 damage to property (79). Thirteen persons were killed in a tornado in southwest Missouri, March 11, 1920, and there was \$100,000 property damage in one town alone (80). Twelve miles northwest of Springfield, April 10, 1922, two persons were killed, many injured, and \$100,000 property damage inflicted by a tornado. During the period 1916-23, 57 tornadoes occurred in Missouri, resulting in the loss of 123 lives. The greatest number of tornadoes in 1 year was 30 in 1917. The greatest loss of life in 1 year was 84 in 1917. Total damage was \$3,500,000. The greatest damage in 1 year was \$1,550,000 in 1917.

During the period 1916-23, 50 tornadoes occurred in Oklahoma with 144 lives lost during that period. In 1920 alone, 64 were killed. During this 8-year period the property damage was \$2,600,000. Damage in 1922 alone amounted to over \$1,000,000. In June 1928 tornadoes accompanied by hail occurred in Oklahoma and southern Kansas, killing 12 persons and injuring more than 100; property damage was estimated at \$4,500,000. In 4



counties around Altus, Okla., 445 houses were destroyed or damaged (81).

During a 15-year period Kansas had 176 tornadoes, resulting in a total of 102 deaths, and total damage of \$9,600,000 (82). The most destructive tornado in the history of western Kansas occurred at Great Bend, November 10, 1925, killing 11 and injuring more than 50; the property damage was estimated at \$1,000,000 (83). Ten persons were killed and 300 injured in the Hutchinson tornado of May 7, 1927, which caused a property loss of \$1,300,000 (84). Eight counties in southwestern Kansas were swept by hail and wind storms from June 16 to June 20, 1928, when damage to crops and buildings totaled \$3,000,000 (85).

In Kansas the most damaging winds are known as "hot" winds. These often sweep from the South during a dry, hot period of summer with shade temperatures ranging from 100° to 110°. They cause rapid desiccation of growing crops. High winds of early spring often cause much damage by blowing off the loose upper soil, especially if it happens to be dry. In such cases soil may be blown from the roots of wheat, or the plant may suffer mechanical damage by rapidly moving particles of sand carried by the wind. In many cases soil has been known to drift like snow along fences or other obstructions (86).

There have been several tornadoes in Texas which have resulted in an appalling loss of life and property. That near Bynum on May 6, 1930, caused the death of 38 persons and a property loss of \$2,000,000. Seventy-two persons were killed and 200 injured in the famous Rocksprings tornado of April 12, 1927. This storm had some interesting, if not unusual, features: it occurred in a semiarid region; it was preceded by hail of baseball size; it apparently had no characteristic funnel-like cloud; and the storm was of surpassing violence (87). In 7 other tornadoes, there was a total loss of 70 lives. A hurricane visited a large area of southeast Texas from August 12 to 14, 1932, killing 40 people and causing a loss of over \$7,500,000. The terrible Galveston hurricane in 1900 and the recent destructive Brownsville hurricane are too well-known to need further attention here.

Fortunately many of the meteorological extremes discussed here may never be experienced again, at least not for generations. On the other hand, new extremes are certain to occur. The resourcefulness of man, however, can be counted upon. Walls to keep out tidal waves, rows of sturdy trees for windbreaks, dams to stop and store flood waters, widespread irrigation projects in areas subject to drought, development of new species of plants better adapted to meet extremes of weather—all these and more will serve to mitigate the ravages of meteorological extremes of the future.

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